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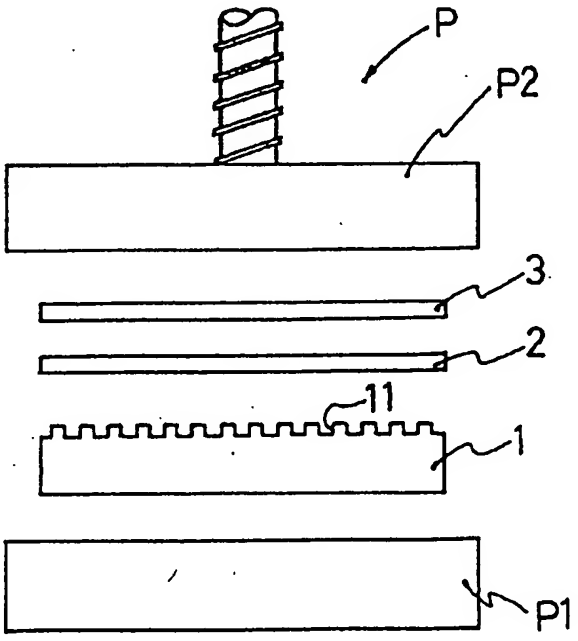
(54) **[Title of the invention]** Forming method of micro fine separation wall

(57) **[Summary]**

[Objective] To provide a forming method of new micro fine separation wall which enables the forming of fine patterns and larger screen which have been the issue in the conventional fabrication method.

[Means to solve] The forming method of micro fine separation wall of this invention is characterized by having a process in which a material of separation wall is filled into finely patterned grooves of the mold, shaped in micro fine stripe or micro fine lattice, a process which laminates these and glass substrate, a process which releases the mold from glass substrate after the said material of separation wall is partially hardened, and a process which completely cures the said material of separation wall and also it is characterized by that a starting material of the mold is semi-cured silicone sheet which is made into sheet by using semi-cured silicone rubber and the sheet is obtained by heat pressing with a master mold. Also, intending to solve above mentioned problem by utilizing the specified features of the invention, micro fine separation wall of desired height can be obtained at one time without the



layer-printing.

[Extent of the Claims]

[Claim 1] The manufacturing method of micro fine separation walls of this invention is characterized by having a process in which a material of separation wall is filled into finely patterned grooves shaped of micro fine stripe or micro fine lattice, a process which layers these and a glass substrate, a process which releases the mold from glass substrate after the said material of separation wall is partially hardened, and a process which completely cures the said material of separation wall and also it is characterized by that semi-cured silicone sheet which is made into sheet using semi-cured silicone rubber, is used as a start material of the mold, and the sheet is heat pressed with a master metal mold and the micro fine pattern grooves shaped in micro fine stripe or micro fine lattice, are transferred and formed.

[Claim 2] A forming method of micro fine separation wall described in Claim 1, characterized by that above mentioned silicone rubber is transparent silicone rubber containing hydrophobic silica by the wet method.

[Claim 3] A forming method of micro fine separation wall described in Claim 1 or Claim 2, characterized by that cured silicone sheet which is transferred and formed with micro fine pattern grooves shaped in micro fine stripe or micro fine lattice is layered with a plate.

[Claim 4] A forming method of micro fine separation wall described in Claim 1 or 2 or 3, characterized by using a mixture for the above mentioned material of the separation wall, composed of the main component which is organo polysiloxanes containing methyl group or phenyl group and the cross-linking agent which is organosiloxane having functional side chain such as alkoxy group, acyloxy group and oxime group and a curing catalyst.

[Claim 5] A forming method of micro fine separation wall described in Claim 1 or 2 or 3, characterized by using perhydropolysilazane as above mentioned material for separation wall.

[Claim 6] A forming method of micro fine separation wall described in Claim 1 or 2 or 3 or 4 or 5, characterized by that above mentioned glass substrate is a glass substrate for plasma display panel.

[Detailed description of the invention]

[0001]

[Technology field where the invention belongs] This invention relates to a forming method of micro fine separation wall which is needed for the separation wall in plasma display or other display panel.

[0002]

[Background of the invention] In a plasma display as simply illustrated in Figure 6, front panel A and back panel B are layered so that the stripe shaped electrodes A1 and B1 oppose each other at a right angle and the light is emitted by discharging at the crossing point in separation wall C of stripe shape or lattice shape. The separation wall C of stripe shape or lattice shape is installed not only for preventing cross talking of the light but for forming a contrast of the display. This separation wall is very fine and recently, in case of stripe shaped wall, it is required to be formed with a dimension of approximately 30 μm wide, 200 μm high and 100 μm apart throughout the entire display.

[0003] This separation wall is formed generally by screen printing and is obtained by so-called layer printing wherein glass paste is printed and dried for about ten times by positioning each time. As other methods, a method has been tried wherein the entire surface of the glass substrate is coated with glass paste, covered with photo-resist and after the exposure and development, the

part which is not covered by resist pattern is sandblasted and baked.

[0004] However, in the method of forming the separation wall by using above mentioned screen printing, the need for positioning each time and deforming of the screen have been the real obstacle in fine patterning and large screen forming. Also, in the latter method using the sand blast, the tendency of irregularity in the depth of blasted part is the obstacle in making fine patterns and larger screen.

[0005]

[Technical features tried for the solution] Therefore, the applicants came to conclude this invention from the concept of forming micro fine separation wall in plasma display by a so-called intaglio printing method as a result of several trials. It will provide a new forming method of micro fine separation wall which enables the creation of fine pattern and larger display which have been the issue in the conventional forming method.

[0006]

[Means to solve the problem] The manufacturing method of micro fine separation walls of this invention is characterized by having a process in which a material of separation wall is filled into the finely patterned grooves shaped of micro fine stripe or micro fine lattice, a process which layers these and glass substrate, a process which releases the mold from glass substrate after the said material of separation wall is partially hardened, and a process which completely cures the said material of separation wall and also it is characterized by that semi-cured silicone sheet which is made into sheet using semi-cured silicone rubber is used as a start material of the mold, and the sheet is heat pressed with a master mold and the micro fine pattern grooves shaped in micro fine stripe or micro fine lattice are transferred and formed. And by means of the specific features of this invention, even in the forming method of layer printing which is intaglio printing style, deforming of the material of the separation wall is prevented because the mold is released after the material of separation wall is somewhat cured. Also, although the mold is usually occupied until the release, semi-cured silicone sheet which is made into sheet by semi-curing the silicone rubber, is used as a starting material of the mold and by heat pressing the sheet by a master metal mold, multiple molds are replicated easily as many as desired and the above described issue is solved while mass production capability is maintained.

[0007] In addition to the above mentioned features, the forming method of the micro fine separation wall described in Claim 2 is also characterized by that above mentioned silicone rubber is transparent silicone rubber containing hydrophobic silica by the wet method. And by means of the specific features of this invention, while the durability of the mold is improved and furthermore, the status of the filling of the material of separation wall is observed and mass production capability is maintained, the solution of the above mentioned problem is achieved.

[0008] In addition to the above mentioned features, the forming method of the micro fine separation wall described in Claim 3 is also characterized by that cured silicone sheet wherein micro fine pattern grooves shaped of micro fine stripe and or micro fine lattice are transferred and formed, is layered with a plate in the above mentioned mold. And by means of the specific features of this invention, handling of the mold becomes easier to be accomplished, especially in a process wherein the mold and glass substrate are laminated and a process wherein glass substrate is released from a mold and the solution of above problem can be achieved.

[0009] Furthermore, in addition to the above mentioned features, the forming method of the micro fine separation wall described in Claim 4 is also characterized by that above mentioned material for separation wall uses mixture composed of the main component of organo polysiloxane having methyl group or phenyl group, crosslinking agent of organo siloxane having

alkoxy group, acyloxy group and oxime group containing functional side chains, and curing catalyst. And by means of the specific features of the invention, the material of separation wall can be cured at a relatively low temperature while good workability is secured and it can be turned into glass and the solution of above problem can be achieved.

[0010] Furthermore, the forming method of the micro fine separation wall described in Claim 5 is characterized similarly by using perhydropolysilazane as the material of separation wall. And by means of the specific features of this invention, the material of separation wall can be cured at a relatively low temperature while securing good workability and can be turned into glass and the solution of above problem can be achieved.

[0011] Furthermore, in addition to the above mentioned features, the forming method of the micro fine separation wall described in Claim 6 is characterized by that above mentioned glass substrate is a glass substrate for plasma display. And by means of the specific features of this invention, micro fine separation wall of plasma display can be obtained at once in the desired height, without layer printing and the solution of above problem can be achieved.

[0012]

[Form of embodiment of the invention] Following is the explanation about the forming method of micro fine separation wall of this invention by referring to several forms of embodiment in the examples of the application shown in the figure. In Figure 1, 1 is a master mold which is engraved with micro fine patterned grooves 11 shaped in micro fine stripe or micro fine lattice which is the opposite shape of the micro fine pattern of the mold described later. Metals which are excellent in rust proof, workability, finish and dimensional accuracy are used for this master mold, and micro fine pattern grooves 11 are formed by precise cutting and electrical discharge machining. These micro fine pattern grooves 11 are formed approximately in 200 μm deep, 60 μm deep and 160 μm apart, for example. When micro fine separation wall in lattice shape is needed, micro fine pattern grooves 11 of micro fine stripe shape are replaced with micro fine pattern grooves of micro fine dot shape which is somewhat orthogonalized pattern of stripes.

[0013] 2 is a semi-cured silicone sheet which is made into sheet shape by semi-curing silicone rubber and although it is plastic in this stage, after a heat curing in the latter process, it will be cured completely and turned into elastic rubber. Also, this semi-cured silicone sheet 2 can duplicate a micro fine intaglio and convex surface by heat curing while contacting some kind of micro fine intaglio/relievo shaped surfaces with a pressure. Among these semi-cured silicone sheet, there is SOTEFA (brand name Sotefa) sold by Toray Dow Corning Silicone Co. Ltd. This is in semi-cured sheet form of approximately 0.6 to 2 mm (thick ?) having an adhesiveness and sold as film shaped, highly transparent silicone rubber adhesive, SOTEFA-70 is supposed to cure about to 70, JIS A Hardness, at 130 °C in 20 to 30 minutes. Also, as disclosed in patent publication Toku Kou Shou 61-56255 and Toku Kou Shou 62-24013, this contains hydrophobic silica by the wet method and it is a highly transparent and fortified silicone rubber. 3 is a plate of such as aluminum which makes handling easy as one part mold by laminating to semi-cured silicone sheet 2 to add stiffness. Yet, it is sufficient if semi-cured silicone sheet 2 is stiffer when cured, this plate 3 is not necessarily be metal but may be fortified glass plate or heat resistant resin plate. Also, in order to reinforce bonding with semi-cured silicone sheet 2, bonding surface of plate 3 can be pre-treated to be rough or treated by a primer and the one which has low thermal expansion is desirable.

[0014] Between a fixed plate P1 and a movable plate P2 of heat press machine P, master metal

mold 1, semi-cured silicone sheet 2 and plate 3 are placed in this order from the bottom, then the movable plate P2 is lowered and left for 25 minutes under the pressure of 50 gf/cm^2, at 130°C and the semi-cured silicone sheet 2 is completely cured. Furthermore, although it is not shown in a figure, in order to add pressure evenly to these, a cushion material which has good heat transmission can be included between the fixed plate P1 and the movable plate P2. After the movable plate P2 is elevated and removed, master mold 1 and semi-cured silicone sheet 2 are pulled apart where they are contacting. On the cured silicone sheet 20 which is a completely cured semi-cured silicone sheet 2, micro fine pattern grooves 11 of the master mold 1 are transferred and micro fine pattern grooves 21 of micro fine stripe shape is formed as the opposite image. Also, at the same time, cured silicone sheet 20 is bonded with plate 3 and micro fine pattern grooves 21 of micro fine stripe is formed as shown in Figure 2 and one part mold 4 which is backed by plate 3 is obtained. A mold may be constructed only with cured silicone sheet without laminating a plate, in this case, thick type semi-cured silicone sheet is necessary. In any case, a mold 4 can be multiplied easily by the master mold 1, many pieces can be prepared at a low cost.

[0015] After the mold 4 is obtained as above, it is positioned on a flat table so that the micro fine pattern groove 21 faces upward, a material 5 for separation wall is filled in the micro fine pattern groove 21 of micro fine stripe shape and the excess material 5 for separation wall is squeezed and removed. When SOTEFA is used as a semi-cured silicone sheet 2 and a transparent material is used for plate 3, this mold 4 is made to be transparent and filling status of the material 5 of the separation wall and filling problem can be detected and it can avoid bad causes before the actual problem happens. It is needless to say that unlike Figure 3 wherein material 5 for separation wall is flowed to fill the entire surface of the mold 4, screen or a simple mask can be put to cover the part except the micro fine pattern groove 21 so that the material 5 for separation wall is filled only into micro fine pattern 21. The material 5 of separation wall can be such as traditionally formulated glass paste which forms black insulation layer after being sintered and its density is increased, in this case, a mixture of heat-less glass (HEATLESS GLASS-trade name) sold by Homer Technology Co., Ltd. which is added with a black pigment and Tospearl (trade name) sold by Toshiba Silicone Cp., Ltd. is used.

[0016] Heat-less glass is so called one-part type silica solution which forms non-crystal ceramic layer and it exhibits hardness and excellent adhesion to several substrates even by low temperature heating and room temperature drying. This is consisted of three ingredients of main component, cross linking agent and curing catalyst and its silica content (as SiO_2) is more than 40 % and it does not contain solvent, water or hydroxyl group. The main component is organo polysiloxane which has methyl group or phenyl group, the cross linking agent is organo siloxane which has functional side chains such as alkoxy group, acyloxy group and oxime group and the curing agent is organic compound containing metals such as Zn, Al, Co and Sn and halogen. The curing mechanism of the heat-less glass starts by that the functional groups of main component of organopolysiloxane undergoes hydrolysis by the moisture in the air and changes to hydroxy groups, then the hydroxy groups of the organopolysiloxane reacts with the functional groups of curing agent of organosiloxane to cause de-alcohol reaction with the effect of the curing catalyst as well and produces three dimensional polymer, that is polysiloxane-based cured substance. The resulting product is metal-alkoxide condensation product prepared by so-called Sol-Gel reaction.

[0017] Also, Tosperal has a three dimensional network structure consisting of siloxane linkages and it is silicone resin, fine particle having an intermediate organic and inorganic structure

wherein one methyl group is bonded to a silica atom, the truly spherical silica particle can be obtained from sintering. Accordingly, when tosperal is added to heat-less glass and sintered, Tospearl turns into silica as well while heat-less glass is soled, gelled and cured and the entire mixture turns to glass. Adding the Tospearl improves thixotropy of heat-less glass in liquid state and can reduce shrinkage at sintering and volume reduction compared to the case when heat-less glass is solely used.

[0018] Next, as shown in Figure 4, a glass substrate 6 for plasma display is positioned on a mold 4 which is filled with material 5 for separation wall. On the surface of the glass substrate 6, stripe shaped, transparent electrodes are formed, which is not shown in the figure. This means that normally, micro fine separation wall is made to form to the glass substrate, after the formation of electrode for address, in case of alternating current type panel and after the anode bus line etching, resister printing, insulation layer printing and anode printing, in case of direct current type panel. The glass substrate 6 and the mold 4 are cramped or loaded so that they are somewhat pressurized, and left at a certain temperature for a certain period of time. These certain temperature and time is set so that the material 5 for separation wall is cured to some extent and released from the mold and the material for separation wall does not deform after the release from the mold, the value setting can not be specified considering the composition of the material for separation wall and others and the value is decided from experience. In any way, when the material for the separation wall is cured to some extent and becomes ready to be released, mold 4 is released from the glass substrate 6 as shown in Figure 5. After this procedure, by performing the heating and sintering to a degree which is appropriate for the material of the separation wall, a glass substrate for plasma display is prepared wherein the separation wall 50 is formed with micro fine stripes of for example, 60 μm wide, less than 200 μm high and 160 μm apart between stripes. As the released mold 4 can be reused if it is not deformed or does not have a small damage, it will be returned to the first process described above and utilized. If there is a damage, the mold can be disposed.

[0019] The above explanation was based on using heat less glass as a material for the separation wall, however, inorganic polymer such as perhydropolysilazane can be used. Perhydropolysilazane is a thermosetting inorganic silazane (ceramic precursor polymer) of which structural formula is [SiHaNHb]n (a is 1 ~ 3, b is 0 or 1), the material for separation wall of which component is perhydropolysilazane fills the micro fine pattern grooves of micro fine stripe or micro fine lattice and sintered in certain atmosphere and at a temperature and becomes hard ceramic layer. For such perhydropolysilazane, there is Tonen Polysilazane (trade name) made by Tonen Corp. It is not necessarily limited to this and ceramic precursor polymer and others can be used as the material for separation wall.

[0020]

[Effect of the invention] The forming method of micro fine separation wall of this invention is consisted of the specific invention features which are described in Claims 1 through 6 which are realized by above described form of application and, by having such specific invention features, several kinds of effects which are explained in the following are realized. Namely, in the specific feature described in Claim 1, even with a forming method that prints thick film by so-called intaglio printing method, micro fine separation wall can be obtained while maintaining mass productivity because it is designed to release the mold in a condition that the material of cured separation wall has been somewhat cured, therefore, deformation of the material of separation wall is prevented, and furthermore, the mold that is occupied until the release of the

mold can be simply replicated as many as desired by using semi-cured silicone sheet which is prepared by forming the semi-cured silicone rubber into sheet, as a starting material, and by heat pressing the sheet with a master metal mold.

[0021] Also, by the specific features of the invention described in Claim 2, micro fine separation wall can be obtained while filling condition of the material of separation wall is verified and the durability of the mold is improved furthermore, and fine patterns and larger screen are realized while mass production is maintained.

[0022] Furthermore, by the specific features of the invention described in Claim 3, handling of the mold, especially the process of layering the mold and the glass substrate and the process to release mold from glass substrate becomes easy and micro fine separation wall can be obtained while fine patterns and larger screen are realized.

[0023] Furthermore, by the specific features of the invention described in Claim 4 and 5, the material for the separation wall can be cured and turned into glass even at a relatively low temperature while good workability is secured and the micro fine separation wall can be obtained while fine patterns and larger screen are realized.

[0024] Furthermore, by the specific features of the invention described in Claim 6, micro fine separation wall for plasma display panel can be obtained, without repeating the layer printing, all in the desired height, and fine pattern and large screen are realized. Plasma display panel was used as an example, however, it is needless to say that this invention can be applied not only to plasma display panel but also to the other purposes which need separation walls with micro fine pattern.

[Figure 1] It shows an example of a process to form micro fine separation wall of this invention which obtains a mold from a master mold with semi-cured silicone sheet as the starting material.

[Figure 2] The same. Side view of the obtained mold.

[Figure 3] The same. It shows the process when material for separation wall is filled into the mold.

[Figure 4] The same. It shows the process when the material for separation wall is cured by pushing the glass substrate to the mold.

[Figure 5] The same. It shows the process of releasing the mold from the glass substrate.

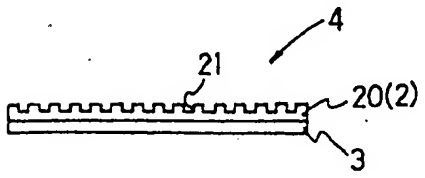
[Figure 6] An outline, oblique view which shows an example of plasma display structure.

[Explanation of the code]

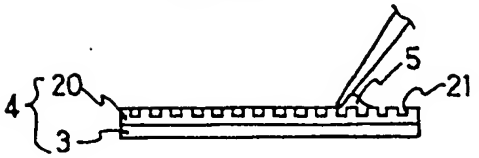
A	front panel
A1	stripe shaped electrode
B	back panel
B1	stripe shaped electrode
C	separation wall
P	heat press machine
P1	fixed plate
P2	movable plate
1	master mold
11	micro fine pattern groove
2	semi cured silicone sheet
20	cured silicone sheet
21	micro fine pattern groove
3	plate
4	mold

5 material for separation wall
50 separation wall with micro fine stripes
6 glass substrate

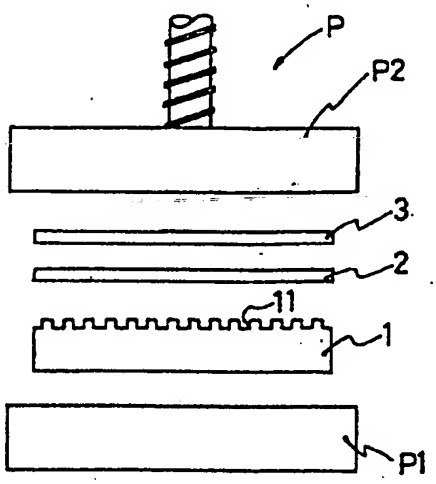
[Figure 2]



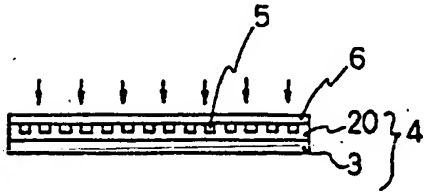
[Figure 3]



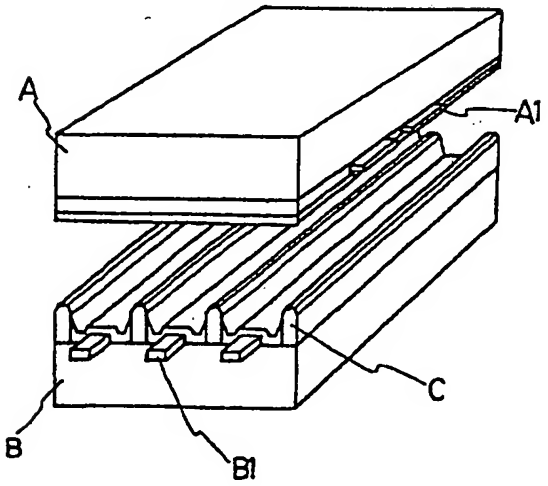
[Figure 1]



[Figure 4]



[Figure 6]



[Figure 5]